632.3
W44
no. 34

Shelved with Quarto.

SUDAN GOVERNMENT.

WELLCOME TROPICAL RESEARCH LABORATORIES.

REPORT

OF THE

GOVERNMENT ENTOMOLOGIST

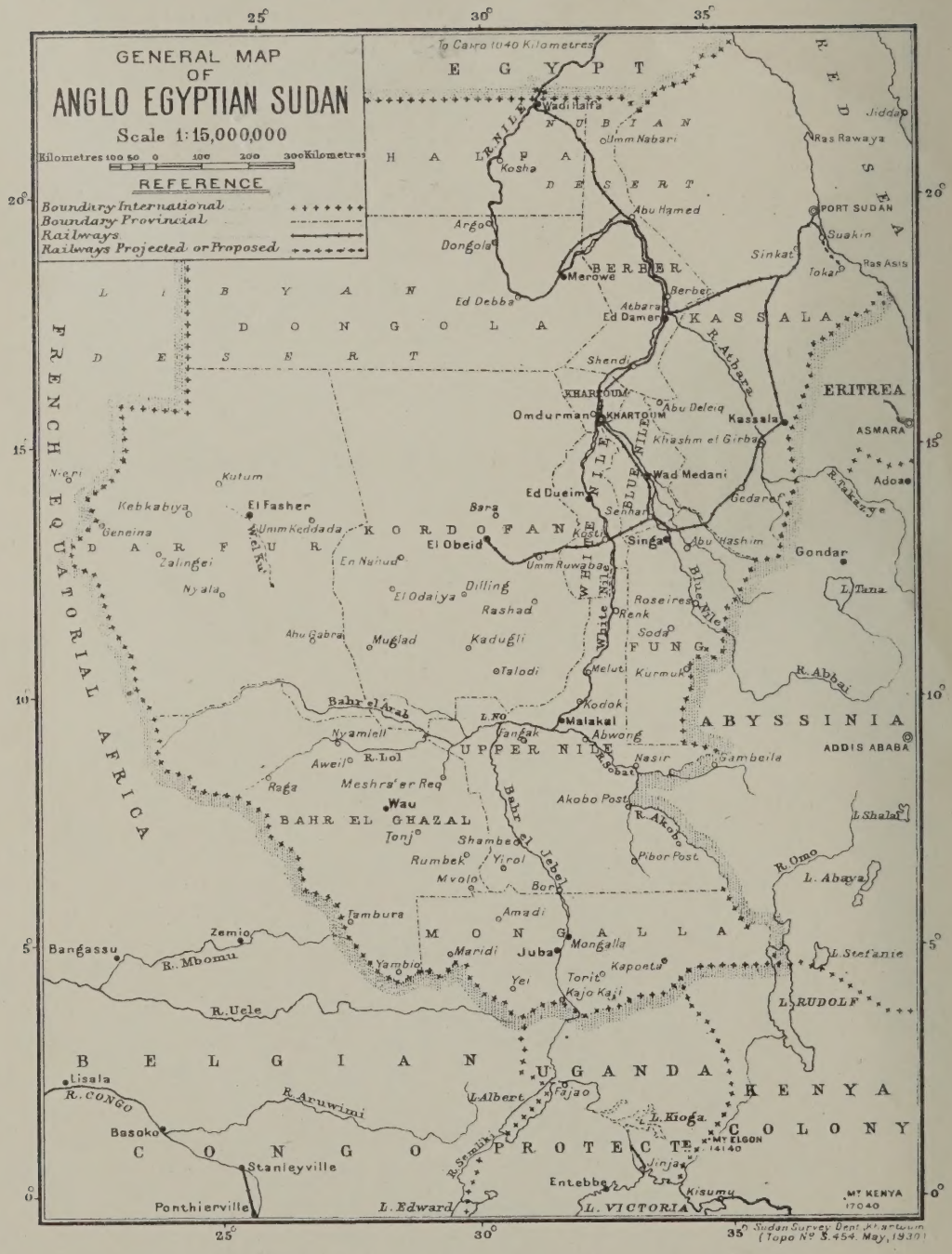
FOR THE YEAR

1930.

Entomological Section—Bulletin No. 34.
January, 1931.

AUG 29 1946

NAT. HIST.


GENERAL MAP
OF
ANGLO EGYPTIAN SUDAN
Scale 1:15,000,000
Kilometres 100 50 0 100 200 300 Kilometres
REFERENCE
Boundary International
Boundary Provincial
Railways
Railways Projected or Proposed
To Cairo 1040 Kilometres
EGYPT
RED SEA
Wadi Halfa
Jidda
Ras Rawaya
Umm Nabari
NUBIAN DESERT
Kosha
Abu Hamed
PORT SUDAN
Suakin
Sinkat
Tokar
Ras Asis
Argo
Dongola
BERBER
Merowe
Berber
Ed Debba
Atbara
Ed Damer
KASSALA
LIBYAN DESERT
DONGOLA
Shendi
R. Atbara
KHARTOUM
Omdurman
Abu Deleig
Kassala
ERITREA
ASMARA
Khashm el Girba
Wad Medani
Adoa
Kutum
Ed Dueim
Gedaref
R. Takazye
Kebkabiya
El Fasher
Bara
Sennar
Blue Nile
Genaina
Umm Keddada
KORDOFAN
El Obeid
Kosti
Singa
Abu Hashim
Gondar
DARFUR
Zalingei
En Nahud
Umm Ruwaba
White Nile
Nyala
El Odaiya
Dilling
Roseires
L. Tana
Rashad
Renk
Soda
Abu Gabra
Muglad
Kadugli
FUNG
Talodi
Meluti
Kurmuk
R. Abbai
Bahr el Arab
Kodok
Malakal
ABYSSINIA
L. NO
Nyamlell
Sangak
Abwong
ADDIS ABABA
Aweil
R. Lol
UPPER NILE
Nasir
Gambeila
Sobat
Raga
Meshra's er Req
Wau
Akobo Post
R. Akobo
L. Shalal
BAHR EL GHAZAL
Tonj
Shambe
Bahr el Jebel
Rumbek
Yirol
Pibor Post
R. Omo
Mvolo
Bor
L. Abaya
Tambura
Amadi
Zemio
MONGALLA
Bangassu
Maridi
Juba
Mongalla
L. Stefanie
R. Mbomu
Yambio
Yei
Torit
Kapoeta
Kajo Kaji
L. RUDOLF
R. Uele
BELGIAN CONGO
UGANDA
KENYA
Lisala
R. CONGO
R. Aruwimi
L. Albert
Rajao
L. Kioga
COLONY
Basoko
PROTECTE
MT ELGON
14140
R. Semliki
Stanleyville
Jinja
Entebbe
Kisumu
MT KENYA
17040
Ponthierville
L. Edward
L. VICTORIA
Sudan Survey Dept Khartoum
(Topo No S.454. May, 1930)

SUDAN GOVERNMENT.

WELLCOME TROPICAL RESEARCH LABORATORIES

REPORT

OF THE

GOVERNMENT ENTOMOLOGIST

FOR THE YEAR

1930.

Entomological Section - Bulletin No. 34.

January 1931.

q 632.4
W44
no. 34

SUDAN GOVERNMENT

WELLCOME TROPICAL RESEARCH LABORATORIES

ENTOMOLOGICAL SECTION.

Government Entomologist ---------- H. H. King.

Assistant Entomologist ---------- H. Bennett Johnston.

Assistant Entomologist ---------- H. W. Bedford.

Assistant Entomologist ---------- T. W. Kirkpatrick.

Assistant Entomologist ---------- J. W. Cowland.

Assistant Entomologist ---------- W. Ruttledge.

Assistant Entomologist ---------- W. P. L. Cameron.

Assistant Entomologist ---------- F. G. S. Whitfield.

Assistant Entomologist ---------- R. C. Maxwell-Darling.

Assistant Entomologist ---------- A. P. G. Michelmore.

Assistant Entomologist ---------- A. H. Wood.

Biologist ---------- A. E. Berlyn.

Laboratory Assistant ---------- R. Cottam.

Bull. ent. Research Dept. no. 34-36 cont mc

C O N T E N T S .

REPORT OF THE GOVERNMENT ENTOMOLOGIST FOR THE YEAR 1930.

INTRODUCTION

by

H. H. King, F.L.S., F.E.S.
Government Entomologist.

There has been one addition to the senior staff of the Entomological Section, rendered necessary owing to a decision to implement a recommendation made by Sir John Harmer that a British entomologist with a knowledge of Arabic should be detailed to lecture for two years on elementary science to students of the Gordon College and to train native lecturers in the subject. Mr. A. N. Wood was appointed in October and posted to Talodi to replace Mr. W. Ruttledge who was transferred to Khartoum to undertake the duties of lecturer.

Locusts. As was anticipated, the desert locust, Schistocerca gregaria again appeared and in numbers believed to have been compared with the numbers which invaded the country in the preceding year. In addition, many large swarms of another species of plague locust, Locusta migratorioides, locally known as the hairy-chested locust, owing to the presence of pubescence on the venter of the thorax, entered the Sudan from the west and spread eastwards throughout the whole of the central and, later, the southern provinces. This latter invasion was entirely unexpected as there was no record of any similar previous invasion. Preparations had been made on a very large scale for dealing with hoppers of the desert locust and the campaign proved highly successful, very few

swarms escaping except in western Darfur where, for reasons given later in this report, intensive control measures were not undertaken. The measures employed against the desert locust proved equally efficacious against the hairy-chested species. The total cost of the campaign - under £E.49,000 - must be considered very small in view of the extent of the areas in which it was conducted and moreover large quantities of materials and equipment remain for use, if required, in the future. The operations in the field were carried out by the administrative staff of the provinces to whom great credit is due, while most valuable assistance was rendered by the Royal Air Force and the Sudan Defence Force. It is not too much to say that without the help of the former the campaign in the northern districts of Kordofan and Darfur could not have been as successful as it was.

The preparations for the campaign, which included the provision of 1,100 tons of dried poisoned bran bait, and later the campaign itself, occupied much of the time of the staff of the Entomological Section during the first ten months of the year, with the result that relatively little research work could be undertaken except by those stationed in the Gezira and at Talodi. Mr. Maxwell-Darling was employed exclusively on locust work throughout the year, Mr. Dowland and Mr. Ruttledge until the end of October, Mr. Michelmore for a period of four months and Mr. Whitfield for two months during the summer and Mr. Bedford and myself for the greater part of the year.

The degree of success which attended the campaign demonstrated the possibility of preventing the desert locust not only from breeding to maturity in appreciable numbers but also from causing other than minor damage to crops in the Sudan.

A study of the habits in the field and the reactions to various conditions in the laboratory of Locusta danica and its phases migratoria and migratorioides was undertaken by Mr. Johnston and Mr. Maxwell-Darling and their results form the subject of a paper which will appear shortly. A paper

or 'baobab' (Adansonia digitata), cotton being the only alternative host plant of importance. From about the end of February when cotton is cut out and until cotton sown at the end of May is in boll they are entirely dependent on tebeldis, sheltering in crevices in the trunks and feeding on fallen seeds on the ground. Not all tebeldis are equally attractive to them, some being almost invariably infested while others rarely if ever harbour them; to what this preference is due is not clear. Trees which produce no fruit are naturally unattractive to them, as are trees from which the fruits have been collected and destroyed. Experiments in pruning and pollarding are in progress to ascertain whether such operations will prevent a tree from fruiting for more than a single season. Pollarding undoubtedly reduces the labour required to collect the fruits but renders the tree unsightly. Colonies of stainers sheltering on the trunks of tebeldis may readily be destroyed by means of a paraffin spray but the cost of this operation if a large number of tebeldis are infested is relatively high. The best time for such spraying is believed to be during March, April and May, the period when there is no cotton on the ground and before the stainers have started to breed rapidly. A reduction in the numbers of tebeldis in the cotton growing areas is clearly desirable but complete eradication cannot be urged as the tebeldi, besides producing a fibre much used by the natives, is held to have a certain aesthetic value when growing among the rugged scenery of the Nuba Mountains. If the tebeldis in such areas are judiciously thinned the work of keeping the stainers under control would not be very costly as regards either labour or materials. The range of flight of stainers emigrating from colonies on tebeldis is believed to be normally about three miles.

Pink bollworm and parasites. A study of the parasites of pink bollworm (Platyedra gossypiella), in particular the Braconid Microbracon kirkpatricki, has occupied a considerable

amount of the time of Messrs. Bedford, Cowland and Wood. Experience both at Tokar and in the Gezira has demonstrated the possibility of controlling this pest by the export from the district or destruction by fire of all seed-cotton, seed (other than sunned seed) and refuse of the old crop early in the dead season but these measures cannot be applied in all cotton growing areas; natives will not readily give up their habit of storing in their houses seed-cotton for spinning and weaving purposes. Under normal conditions a proportion of the pink bollworm in a cotton crop may be expected to be destroyed by parasites, of which M. kirkpatricki is the most common, but this proportion is rarely high. If it were possible to ensure an adequate stock of the parasites among growing cotton from the time when bolls are first formed, pink bollworm should be prevented from becoming sufficiently plentiful to cause serious loss. Another and probably the original host of M. kirkpatricki is a Lepidopterous larva (Crocidosema plebeiana) not unlike pink bollworm in appearance, which feeds in the seed heads of the perennial weed 'hambuk' (Abutilon spp.). A study of the incidence of M. kirkpatricki on hambuk in Khartoum throughout the year has indicated that there is a marked increase in the numbers of this Braconid at the time when cotton is beginning to boll. It would appear possible therefore that hambuk grown in the vicinity of cotton might serve as a reservior of M. kirkpatricki particularly during the dead season and the period immediately following it before the new crop begins to boll. Experiments in this direction are in progress and a search is being made for other parasites likely to be of value in this.

Early in the year several consignments of living material of M. kirkpatricki were sent to the Plant Protection Section, Egypt and also to the Farnham House Laboratory, Bucks, England. From the latter institution consignments were relayed on to Texas, where as in Egypt, this parasites is required to aid in

the control of pink bollworm.

Collections and Records.

A large amount of material has been added to the collections and 2117 specimens have been sent to the Director, Imperial Institute of Entomology for identification. A total of 1446 determinations have been received representing 531 species of which 31 were new to science and a further 38 species were unrepresented in the collections of the British Museum.

Illustrations.

Considerable progress has been made in the preparation of illustrations of injurious insects, a total of 31, of which 14 are in colour, having been completed.

Third Imperial Entomological Conference.

Mr. Johnston and I, while on leave, attended on behalf of the Sudan Government the Third Imperial Entomological Conference held in London in June. Messrs. Ruttledge, Cameron, Whitfield and Maxwell-Darling who were on leave at that time also attended a number of the meetings.

Conclusions.

A large proportion of the time of the staff has, as in previous years, been occupied in routine work which includes the inspection of crops, particularly in the Gezira where Mr. Johnston has as far as possible kept the entire irrigated area under regular observation throughout the season. Work of this nature, while naturally limiting the amount of research which may be undertaken, is believed to be an essential and by no means the least important part of the duties of the Section.

AN ACCOUNT OF THE LOCUST CAMPAIGN OF 1930.

by

H. H. King, F.L.S., F.E.S.

Introduction.

One of the outstanding features of the past season, the fourth in the present cycle of locust years, has been the appearance of large numbers of swarms of Locusta migratorioides, known locally as "kaboora" or the "hairy-chested" locust. The solitary phase of this locust Locusta danica, has a wide distribution in this country but is of no economic importance, though the migratory phase Locusta migratoria, which is the plague locust of Russia, has been noted on several occasions in small swarms on the maritime plain bordering the Red Sea from Port Sudan to Tokar. The migratory phase Locusta migratorioides is recorded as appearing occasionally in the Cameroons, Togo and Kilimanjaro while it is a serious pest in Madagascar but there was no record of it ever having occurred in the Sudan. On its arrival in Darfur Province this season it was recognised by older natives as having appeared as a plague in two successive years some forty years ago and there is no reason to doubt the accuracy of this statement. While the desert locust, Schistocerca gregaria, seeks for light, sandy soil in which to oviposit, the hairy-chested locust seems to prefer a heavier soil in which to place its eggs, consequently hoppers of this latter species occurred in regions in which hoppers of the desert locust had not been known and in which no preparations for destroying hoppers had been made. Further, a female desert locust is believed to deposit only one, or at the most two batches of eggs but a female hairy-chested locust apparently can deposit a succession of egg batches. As a result therefore of this visitation of L. migratorioides the areas over which the destruction of hoppers had to be carried out was considerably larger than there had been any reason to anticipate and the hopper season was unusually prolonged.

As far as could be judged, approximately as many locusts entered the Sudan during the early summer as in the previous season and it is probable that the numbers of hoppers bred in the country also equalled if they did not exceed those of 1929. The rains were rather lighter than last year and in the northern districts were late but there was no lack of rain-moistened soil suited to the breeding requirements of the two species.

Outline of the campaign.

The standard method adopted for the destruction of locusts was that of poisoning the hoppers by means of sun-dried poisoned bran bait. It had been proved that this bait, which was first prepared during the winter 1927-28, might be kept in store for at least two years without deteriorating to any appreciable extent and experience in the field had indicated that it was both convenient to use and effective against hoppers. An estimate was made of the amount of bait which would be required to deal with an invasion of locusts of similar proportions to the invasion of 1929 and of the facilities which would be needed for its preparation and storage.

Of the areas frequented by the desert locust for 'kharif' breeding northern Kordofan was considered to be one of the most important and at the same time the most difficult in which to carry out control measures. It comprises more than 30,000 square miles of desert, very sparsely inhabited by nomads, who when the rains begin migrate northwestwards with their herds. There are but few wells and the nature of the ground is such that motor transport cannot be made use of during the rainy season. Hoppers in this region can cause but little damage as only relatively small areas are cultivated, but the resulting fliers are a menace to crops in other regions. In Darfur crops are of only local value owing to transport difficulties and here again the reason for undertaking the destruction of hoppers was, apart from the risk of local grain shortage, the risk of fliers bred there moving eastwards to regions such as the Nile valley and the Gezira. It was recognised that in both northern Kordofan and Darfur the total quantities of bait

required would have to be stored locally as owing to the distances involved and the lack of any form of transport other than camel, it would not be possible to send supplementary supplies during the hopper season. Except in these two regions the approved scheme provided for the storage of small supplies of bait at convenient centres throughout the areas likely to be infested with hoppers and a sufficiently large reserve in Khartoum to be drawn on as required.

Facilities for the preparation of bait.

The preparation of bait consists of moistening wheaten bran with a dilute solution of arsenite of soda and treacle in water and then drying out the water by exposure to the sun and air. When airdry the bait is packed in cotton bags, each containing about 2¾ gallons, the mouths of the bags being tied up with fine cord. The bags are in turn packed in sacks, eight bags to a sack, and the mouths of the sacks sewn up with string. The poison solution is prepared by dissolving arsenite of soda in hot water and stirring the hot solution into treacle; the resultant mixture requires only dilution with water to be ready for incorporation into the bran.

A site for a concrete drying floor of 4,000 square metres was selected in Khartoum North adjoining a large building which the Director of Supplies, Sudan Defence Force had offered for the storage of bran and bait; the position of this store was eminently suitable as it was already served by a railway siding and was within a few yards of the river. It was estimated that this area would permit of the drying of fifteen tons of bait daily. Water was laid on and five tanks provided from which water might conveniently be dipped for the dilution of the concentrated poison solution; nearly 4,000 gallons of water was required daily within the space of two hours. For the preparation of the concentrated poison solution two tanks were placed on a masonry base and so arranged that the upper and smaller one in which the arsenite of soda was dissolved could be emptied by gravity through a tap into the lower one containing the

treacle; this latter could in turn be emptied by the same means into drums. A stove placed immediately under the smaller tank permitted of the water in which the arsenite of soda was dissolved being readily heated. Three hundred-weight of arsenite of soda could be dissolved at a time in this tank. A corrugated-iron shed was erected for the storage of sacks, bags etc., and an area in front of the shed roofed to provide shelter from the sun for the men engaged in sacking the bait. For the transport of the bran and bait to and from the floor three Morris elevating trucks with nine wooden carriers were obtained through the Public Works Department.

The whole of the area utilised for the preparation of bait was enclosed in an unclimbable wire netting and barbed wire fence. A plan of the drying floor and store is figured.

It was hoped that the floor with tanks, water-supply and other facilities would be ready for use by the end of February but actually the work of construction was not completed until the 31st March. As the preparation of the bait had to be completed before the onset in Khartoum of the rainy season this delay in the construction of the floor resulted in a shortening of the period available for the work.

Quantities of bait prepared and materials used.

The amount (in bulk) of bait which results from treating a ton of bran with locust poison solution depends on the quality of the bran. A ton of fine, mealy bran will result in well under thirty sacks of bait but a ton of bran consisting of large, clean flakes will produce nearly forty sacks of bait. In estimating the amount of bait required for the campaign it was taken that 35 sacks of bait would be prepared from a ton of bran.

It was estimated that 17,500 sacks of bait would be required for Darfur, a similar quantity for northern Kordofan and a similar quantity again for the rest of the Sudan, in addition to the relatively small quantities, amounting to 1,679 sacks, which remained

from that prepared in the previous year. The preparation of this amount of bait would have entailed the purchase of 1500 tons of bran.

The delay in the construction of the drying floor rendered necessary the reduction of the quota for Darfur as it was essential that all bait for that province should be in store at the various centres before the beginning of the rains. It may be noted that the journey from railhead at El Obeid to El Fasher by camel occupies twenty-tow days. It was therefore decided that as regards Darfur the campaign should be restricted to the north-eastern district for which 5250 sacks (the equivalent of 150 tons) should be provided.

The amended estimates called for the purchase of 1,100 tons of bran, 20 tons of arsenite of soda and 13,200 gallons of treacle. In addition, 396,000 cotton bags, each to contain approximately 2¾ gallons of bait and 40,250 sacks were required. The Director, Supplies Department, Sudan Defence Force undertook to purchase and store the bran and to store and issue the bait. He also undertook to purchase the sacks. The Director, Stores and Ordnance Department arranged for the supply of the bags. Owing to the bran purchased proving to be of better quality than was anticipated each ton resulted in 38 (instead of 35) sacks of bait, consequently there was an increase over the estimate in the reserve of 3,300 sacks.

Preparation of bait.

The preparation of bait was begun on the 2nd. April and completed on the 1st. July. Some 150 natives were employed daily and except on days of unusually high humidity, when the drying of the bait was retarded, fifteen tons of bran could be dealt with. The men were divided into gangs of nine to twelve, each under its own sheikh. Of these gangs, one was engaged in the preparation of poison solution, ten in the mixing and drying of bait, one in the distribution of bran and poison solution to the gangs using it and in general cleaning up and one in marking sacks. The work began at 5 a.m. when the gate to the floor was opened and the ten gangs employed in mixing bait carried each a few sacks on to the floor

together with their tools. At 5.30 a.m. poison solution was issued and the actual mixing of bait started. Each gang had a definite quantity of bran to poison and a definite area of floor on which to spread it but might not begin to spread until its quota of bait had been passed as properly mixed. By 8 a.m. at the latest the bait had been mixed and spread, vessels used for carrying dilute poison solution washed, and the men had left for breakfast. After breakfast three of four men from each gang raked the bait at short intervals until it was airdry while the remainder sacked the bait prepared on the previous day. Usually the bait was dry by 1 p.m. when it was bagged and carried to the shed. Work for the day normally ceased at 2 p.m. but sometimes when drying was slow continued until 3 p.m. or even later.

The work was very closely supervised by British and Native staff of the Entomological Section to ensure both that the bait contained the correct proportion of arsenic and to reduce the risks of accidents to the natives employed. All natives engaged in mixing bait wore rubber boots and those who handled the poison solution wore, in addition, goggles to protect their eyes from splashes. The rubber boots were washed daily, inside and out. No native was permitted to wear his own shoes within the enclosure lest they should become impregnated with arsenic. Anyone wishing to drink repaired to the zeer shelter where he was handed a mug of zeer-cooled water by the man in charge of drinking facilities. On leaving the enclosure, whether for breakfast or at the close of the day's work, every man was required to submit his hands and feet for inspection; if they were not considered clean he was sent back to wash. Ample facilities as regards water, a tank and soap were provided for washing both the person and clothes. Any man reporting sick was sent to the local hospital and the Medical Officer warned of the possibility of the indisposition being due to arsenical poisoning. Latrines were provided within the enclosure to obviate the necessity of men leaving the enclosure except for breakfast and at the end of the day's work. Every effort was, in fact, made to reduce to the minimum the risks of accidents to the natives and

a satisfactory feature of the work was that no man engaged on it suffered other than possibly a passing indisposition as a result.

The amount of bran required for conversion into bait was issued daily to the entomologist in charge of the floor by an official of the Supplies Department.

Issue and storage of bait.

Each day the bait, bagged and sacked and ready for transport or storage, which had been prepared on the previous day was handed over to an official of the Supplies Department, Sudan Defence Force. Until the end of May, when the immediate requirements of the provinces had been met, it was loaded straightway into railway trucks or river barges for despatch; the bait prepared during June was stacked in the store to constitute the reserve.

The two chief factors to be reckoned with in connection with the storage of bait are termites and moulds; sacks and bags are liable to be eaten by the former while if the bait is allowed to become damp in store it is attacked by the latter and rendered unattractive and unpalatable to locusts. Except in Darfur and northern Kordofan, most of the bait was stored in merkaz stores or other permanent buildings, the remainder being stacked near desert wells on ground sheets under small tarpaulin covers. In Darfur it was stored in specially constructed huts, each containing seventy sacks, while in northern Kordofan it was stacked on large white-ant proof mastabas and covered with tarpaulins. A few sacks were damaged by rain but, generally speaking, the storage arrangements appear to have been very satisfactory.

Antidote.

Twenty-six small boxes, each containing a supply of doses of antidote for use in case of arsenical poisoning, were issued. As far as is known occasion arose for the administration of only a single dose.

Equipment issued for use in the field.

Equipment issued for use in the field included fantasses (of which 200 were purchased from the Stores and Ordnance Department and others borrowed from various departments), water-skins and nets, safias, oil and soap, in addition to tents and small canvas covers and ground sheets. Of the tents some were the property of the Entomological Section but most were loaned by the Stores and Ordnance Department. The canvas covers (170 in number) were designed each to fit over a stack of ten sacks of bait to afford protection from rain.

Arrival of locusts.

The immigration into the Sudan of the desert locust began in May and probably ended by the 31st July. Flights came from two directions - the east into Kassala Province and the west into Darfur, in each case many swarms continuing on their course until all those areas suited to the 'kharif' breeding of this species were well stocked with adult locusts. Possibly also a few swarms reached Kordofan from the north-north-west, via Dongola Province but there was no clear indication of this. There is reason to believe that a larger proportion came from the west than was the case last year.

The first definite news of the arrival of the hairy-chested locusts was received in July when very large flights entered Darfur coming from French Equatorial Africa but there is a possibility that a few flights of locusts reported as travelling northwards over Upper Nile Province in May belonged to this species and that others entered Fung Province from Abyssinia. Those from the west are suspected to have originated in reed beds in the vicinity of Lake Chad but if any came from Upper Nile Province they may have bred locally in the Sudd Region. Of the flights which entered Darfur some stayed to oviposit while others scattered eastwards at least as far as the White Nile. The flights of this locust which oviposited in Blue Nile, Fung and Kassala Provinces may have come from the south or from Abyssinia but, alternatively and far more

probably were part of the main immigration from French Equatorial Africa.

Egg-laying.

Egg-laying by the desert locust was first seen on the 2nd. July, in Kordofan and by the end of that month it is believed that a large proportion of the swarms had oviposited. The latest date on which this species was seen to oviposit - except on the Red Sea littoral where breeding continues throughout the winter - the 22nd. September.

Egg-laying by the hairy-chested locust also started early in July; in the majority of the reports of egg-laying no distinction was made between the two species, but hairy-chested hoppers were seen emerging on the 20th July. Eggs were reported as having been laid in Upper Nile Province in November and breeding continued until the end of the year in that province and in Mongalla and Bahr el Ghazal Province.

Hoppers.

As with eggs, only a proportion of the reports of the occurrence of hoppers included information as to which species was referred to. It must be remembered that the appearance of the second species, Locusta migratorioides, was entirely unexpected and observers in the field had not, early in the season, been asked to note to which species hoppers or adults belonged, nor had they been told how the two species might be differentiated.

As already noted, the desert locust prefers to oviposit in light sandy soils and such soils are not found usually much south of parallel 13. The hairy-chested locust, on the other hand, appears to prefer a heavier soil and although throughout a relatively narrow belt running from east to west across the Sudan the two species bred together there was a definite northern limit beyond which this species was not known to oviposit. The southern limit of the breeding of the desert locust and the northern limit of the

breeding of the hairy-chested species are illustrated on Plate I.

An unusual feature of the season was the lack of desert hoppers in the northern districts. Very few hoppers occurred in those areas of Khartoum, Berber and Dongola Provinces which were expected to be heavily infested and the same applies to the Butana district of Kassala Province. Another unusual feature was the late breeding of this species - our records indicate that egg-laying usually ceases early in August but this year eggs were laid in the latter half of September and hoppers were being dealt with up to the end of October.

Emigration of locusts.

The flights of the desert locust which matured in Darfur outside the area in which poisoning operations were carried out are believed to have flown westwards or north-westwards into French Equatorial Africa. Very few flights matured elsewhere and these apparently travelled eastwards towards the Red Sea. The locusts which oviposited on the coastal plain between Tokar and Khor Arbaat in November and December were presumably from these flights or alternatively they were bred in Eritrea, Abyssinia and Somaliland. One flight was recorded to have left for Arabia.

Of the hairy-chested locust a number of flights are known to have matured in long-chested country in Darfur, Western Kordofan, Upper Nile and Fung Provinces. In these areas hoppers of the desert locust do not occur and consequently no preparations had been made for dealing with locusts. Flights bred in Darfur left for the west and a few flights are believed to have entered Abyssinia from Fung. Flights bred elsewhere moved southwards and as already stated, continued to breed until the end of the year in Upper Nile, Mongalla and Bahr el Ghazal Provinces.

The destruction of locusts.

In a few cases attempts were made to dig up the eggs but the results obtained were held not to justify the labour involved. The vast majority of the hoppers killed died as a result of ingesting

poison bait but wherever newly emerged hoppers, too young to feed, were found they were beaten with branches of trees; very large numbers were destroyed in this way. Again, in Darfur, large numbers were destroyed by burning; where hoppers had congregated in dead grass remaining from the previous season's rains, the grass was fired and the remnants of the swarm then poisoned. In Kordofan a number of flights of newly matured adults were killed by means of poison bait; it was found that if the bait were scattered over night around bushes in which such locusts were resting they would descend and eat it at daybreak the following morning.

The general plan of campaign was as follows. Each bait centre or dump was in the charge of a responsible official termed an area controller and the area served by any dump was patrolled by men mounted on camels. When one of these scouts found or received news of hoppers he reported to the area controller who sent out a poisoning gang in the charge of a policeman; the poisoning gang would remain out until it had destroyed all the hoppers in the district when, unless other orders had been received from the area controller, it would return to the dump. The area controller was responsible for keeping the poisoning gangs supplied with bait and other necessaries and for reporting to the Province Governor when further supplies of bait were required at the dump.

An attempt has been made to arrive at some figure which will represent the quantity of locusts destroyed. It is estimated that 1 lb. of moist bait is sufficient to kill twenty lbs. of hoppers if economically used but as used by natives probably it kills only 10 lbs. of hoppers. The total amount of dry bait used was approximately 629 tons; this quantity when moistened would weigh 1,527 tons, and should have killed 15,270 tons of locusts. In addition very large numbers of new emerged hoppers were destroyed by beating with branches of trees, while in dry grass country in Darfur large numbers were killed by burning. It is believed that the total weight of locusts destroyed must have been well in excess of 10,000 tons.

Efficacy of the bait.

Early in the season two reports (the second unconfirmed) were received to the effect that bait was not proving effective against hoppers of the hairy-chested locust. Other reports stated that hoppers of this species took the bait readily and died as a result. A study of their habits indicated that when crossing ground bare of vegetation they were apparently not expecting to find food and were apt to pass bait unnoticed but when feeding among vegetation bait was more attractive to them than the vegetation itself. Hoppers of the desert locust never fail to detect the presence of bait on bare ground and consequently it is customary to scatter it on any bare area in the path of a moving swarm.

Except for the above mentioned instance all reports on the use of bait indicated that it gave most satisfactory results, proving attractive to hoppers and newly matured adults of both species and causing the deaths of those feeding on it usually within the course of 24 hours.

Records of the occurrence of locusts.

Forms for recording the occurrence of flying locusts, eggs and hoppers respectively were distributed to all officials likely to be able to furnish the required information. A summary of the locust situation together with copies of reports received were sent at the end of each month to the following :-

The Civil Secretary, S.G., Khartoum.
The Financial Secretary, S.G., Khartoum.
The Director of Agriculture and Forests, S.G., Khartoum.
The Director, Commercial Intelligence Branch, C.E.B., S.G., Khartoum
The Sudan Agent, Cairo, Egypt.
All Governors of Provinces, S.G.
The Director, Plant Protection Section, Giza, Egypt.
The Government Entomologist, Palestine Government, Jerusalem.
The Director of Agriculture, Asmara, Eritrea.
The Director, International Locust Bureau, Damascus, Syria.
The Secretary, The Economic Advisory Council, London.

The Government Entomologist, Pretoria, Union of South Africa.

M. P.Regnier, Chef de la defence de culture, direction general de la Agriculture, Rabat, Maroc.

Director of Agriculture, Berbera, British Somaliland.

The Government Entomologist, Kampala, Uganda.

The Government Entomologist, Nairobi, Kenya.

Use of aircraft.

The Officer Commanding, 47th Bomber Squadron, R.A.F. maintained one aeroplane at Kuttum from the 5th August until the 20th September and another at Soderi from the 19th July until the 20th September for the use of the officials in charge of locust operations in Darfur and Northern Kordofan respectively. These officials were thus enabled to visit the various centres within their regions at frequent intervals and keep in close touch with the work which was being done. Mr. Watt, the official in charge of locust operations, Northern Kordofan, was actually in the air for more than 100 flying hours; his only alternative means of transport was by camel and had he been without the services of the aeroplane he would have been able to visit each post possibly once during the season. There can, in fact, be no doubt that the aeroplanes were of very great value.

Assistance given by Sudan Defence Force.

Apart from the help given through the Director, Supplies Department in purchasing and storing bran and in storing and issuing bait, the Sudan Defence Force rendered assistance in actual locust destruction. The Officer Commanding, Western Arab Corps (Darfur) maintained a company in the field throughout the hopper season while the Officer Commanding, Camel Corps (Kordofan) also maintained a company in the field for a similar period. In each case the company took entire charge of a definite area making its own arrangements for transport etc. Further, the Officer Commanding, Western Area, despatched four cars of the Motor Machine Gun Battery under a British Officer to a point in the uncontrolled area in Darfur to carry out poisoning operations against hoppers. It is unnecessary to stress the value of this assistance.

Damage caused by locusts.

A little damage was caused early in the season by immigrating flights of the desert locust to crops on pump schemes in Berber and Dongola Provinces and in the Gash delta, seedling cotton in particular being attacked. As far as is known all cotton so destroyed was resown. No damage was recorded as having been caused by desert hoppers and a negligible amount by fliers bred in the country. A certain amount of local damage was caused by hairy-chested hoppers and later by adults in southern districts but the total value of crops destroyed was small.

The above remarked do not apply to those parts of Darfur not included in the campaign area. There, very serious damage was caused by hoppers and fliers of both species.

Cost of the campaign.

The total cost of the campaign including the capital expenditure involved in the construction of the drying floor etc., and the clearing of roads and landing places for aeroplanes was less than £E.49,000. The estimated value of the drying floor etc., materials and serviceable equipment available for use next season is approximately £E.20,000.

Conclusion.

The success with which the campaign was attended must be attributed to a very large extent to the whole-hearted and even enthusiastic cooperation of all officials and others concerned. Some idea of the magnitude of the undertaking may be gained from a study of the extent of some of the areas in which hoppers occurred. For example, White Nile Province comprises 16,700 square miles, the infested areas of Kordofan some 59,600 square miles, and the north-eastern district of Darfur some 15,000 square miles. In his report on the work in the last-named district, Major Evans, the official in charge states "As regards this area, it has been quite definitely demonstrated that, provided enough bait is on hand and the area is inhabited, the maximum number of swarms within living

memory can be dealt with so effectively as to prevent any damage at all except in the old case when a swarm actually hatches out in a cultivation."

"Reliable native opinion in Mellut agreed that the present year's visitation of locusts is the heaviest known since sannet dereisa about 40 years ago, and that but for the supplies of bait there is not the slightest doubt that there would have been a famine in spite of the very excellent rains."

"The hordes of locusts reported from certain other parts of the province where no bait was available show that this year's invasion of locusts is an exceptionally heavy one."

One of the advantages attaching to the use of dried bait as compared with other methods of destroying hoppers has been well brought out during the campaign. If burning, trenching, erecting barriers, digging pits etc., are resorted to a very large amount of labour is required; it is usually necessary to call out all inhabitants of an infested area with the result that their normal duties as cultivators are neglected. Further, as they cannot be paid for such work they tend to be resentful rather than grateful for the efforts made by Government to destroy locusts. The use of dried bait calls for but little labour and consequently while a small proportion of the population is engaged in scouting and poisoning, the remainder may continue working among their crops. The few who are employed in locust destruction should naturally be remunerated but the cost of such remuneration is relatively small. Natives of districts in which poisoning operations have been carried out are undoubtedly alive to this advantage.

When sundried bait was first prepared it was realised that unless it could be stored without suffer deterioration for at least two years so that any bait remaining over at the end of a campaign might be used the following season, its use on a large scale might prove wasteful. Bait which had been in store for thirty-two months was used in December against desert hoppers and found to be little if at all inferior as regards either attractibility or toxicity to

bait which had been in store only eight months; it is probable that it will withstand storage for a considerably longer period.

The value of the campaign lies perhaps less in the preservation of the crops of the past season than in the fact the possibility of preventing locusts from breeding in the Sudan, and at what must be considered a very moderate cost, by means of dried bait has been demonstrated.

On the Study of another Sudan locust (Locusta migratorioides Rch. and Frm.) in 1930.

by

H. B. Johnston, M.A., C.M.Z.S., F.E.S.

The locust best known to residents in the Sudan is the Desert Locust (Schistocerca gregaria, Forsk.). For the last four or five years the country has been subjected to inroads of this species which have called for the carrying out of organized control on a large scale. Swarms arrive from various directions, but chiefly from the east, and produce one or more generations during the summer rains, and which again leave the country in the autumn. During the period July to September 1930 there arrived swarms of another species which, according to native accounts, had not been seen in the country for over 40 years. These entered from the west only, and they are supposed to have originated in territory west of Darfur probably in the region of Lake Chad and the Niger basin. The individuals composing these swarms differ from those of the better known Desert Locust, which occurred at the same time, in being smaller and possessing a much less vivid yellow colour. The wing covers or elytra moreover are less definitely marked, the head is distinctly larger than in the

Desert Locust, and the under side of the thorax is covered by a dense grey pubescence, a characteristic which suggested the name popular in the Sudan - "Hairy-Chested Locust." These swarms laid eggs in suitable places over a wide area, and the hoppers, which feed on grasses and graminaceous crops, were of a dense velvety black colour above and dull orange or orange-yellow beneath. These on maturing gave rise to winged adults which resembled their parents in every respect except in their possession of two dorsal dark areas on the thorax (pronotum). These, however, are temporary only and characterize the early period of adult life, disappearing with the assumption of the yellow colouration which accompanies the development of sexual maturity.

Owing to the somewhat indefinite state of knowledge concerning the swarming locusts, this species both in regard to its range of distribution and habits is very imperfectly known. The opportunity for its study offered by its presence in the Sudan could not be lost and during the autumn and winter of 1930 an attempt was made to ascertain certain facts regarding its habits and phase relationships. The fuller account of this work, of which this is merely a summary is in course of publication, in another place.

Phases.

The theory of phases (Uvarov) has been now found to apply to at least three of the Old World locusts. This theory postulates the existence for each swarming locust of a solitary and a gregarious phase. Individuals of the former phase live singly and scattered over a certain area and during favourable periods, usually characterized by copious rain-fall and abundant food, give rise to the gregarious phase, which on reaching a certain point migrates in swarms beyond the boundaries of its place of origin and often for long distances.

The proper understanding of the phases of locusts and their interrelationships is one of the most important aspects of their study, and one which when more fully worked out will undoubtedly throw fresh light on the question of their control. The theory

was first clearly formulated by Uvarov (L.migratoria, L.) in Russia. In 1924 the writer first obtained this locust by crowding in cages the larva of a common Sudan solitary locust (L.danica, L.). From work done in 1924 and 1926 it was abundantly evident that the experimental production of a gregarious phase from the solitary phase was possible in the Sudan, but the former had never been encountered under natural conditions. The arrival of swarms in 1930 provided the desired opportunity for establishing the connection of the solitary and gregarious phases.

The facts now known on this subject may be briefly summarised. Three locust-forms hitherto described as and believed to be distinct species are concerned, namely Locusta danica, L., L.migratoria, L. and L.migratorioides, R. and F. These are known to be but forms of one species which has its phase solitaria (= L.danica) and phase gregaria (= (a) L.migratoria and (b) L.migratorioides). Their inter-relationships as observed in breeding cages are as follows: Phase solitaria when crowded gives phase gregaria (a) and when heavily crowded may approximate to (b) but has never quite reached it. The latter has only been met with under natural conditions. The reverse process also is possible namely the production of adults of phase solitaria from larvae of phase gregaria (a) or (b) by rearing them singly. The rearing of a moderate number of larvae of phase gregaria (b) gives (a) or a variety of forms more nearly approaching phase solitaria (= phase dissocians), similarly crowding of larvae of phase solitaria may in certain circumstances, not fully understood, give rise to an intermediate condition (= phase congregans).

The differentation of the phases is made on certain structural characters namely the shape of the pronotum and the ratio existing between the length of certain parts of the body especially the lengths of elytra and hind femora, usually referred to as $\frac{E.}{H\ F}$. Colour differences though striking and of some value are unreliable when taken by themselves.

Observations in the field when compared with those from examples bred in cages are of extreme interest. Phase solitaria under conditions of heavy rain-fall (Red Sea Coast 1925-26) gives rise to an incipient swarming phase (congregans) but has never been known to go farther in the Sudan towards the phase gregaria. The latter, as far as the northern Sudan is concerned must come from outside. It enters the country as phase migratorioides and produces one generation, which resembles the parents if the swarms are large, but turns to phase migratoria if the swarms are small. These leave the northern Sudan and can continue breeding in the southern districts (Mongalla etc.) throughout the winter. At the time of writing reports from Uganda and north-west Kenya speak of swarms arriving from the north. It would appear therefore that whereas the Desert Locust follows a definite yearly route between its summer and winter breeding grounds, this species sends out from certain large breeding centres swarms which do not return. In this respect it agrees with the observed habits of the Asiatic Locust in Russia.

Habits of phase migratorioides.

Egg-laying by the female members of migrating swarms may be spread over a prolonged period. Whereas the Desert Locust deposits eggs in one locality and then dies, migratorioides lays during a brief halt of the swarm on suitable grounds, or a portion of a swarm may even remain behind, lay eggs and continue flight with the same or a following swarm.

Elevation of swarms is low and members of a previous swarm have been observed to join a following one after having passed the night and laid eggs. The largest number of egg-pods recorded for one female is eleven. The number of eggs averages 59 per egg-pod and varies considerably between 40 and 70.

Occasionally in about 10% of cases over 100 eggs may be found. Eggs may be laid in any type of soil, and unlike the Desert Locust this species does not limit itself to sand or soils of coarse texture. Thus egg-laying took place liberally in the irrigated

Gezira plain in soil containing up to 61.5% clau. The mechanical analyses of three samples of soil in which eggs were laid, for which I am indebted to the Government Chemist, Khartoum, may be given here :

Stones and Gravel %	Coarse sand %	Fine sand %	Silt %	Clay %
1.5	6.1	12.6	18.2	61.5
2.8	18.5	15.7	10.7	52.3
5.6	25.8	14.1	9.9	44.7

Of several hundreds of egg-pods laid in cages in soil of this composition 95.7% hatched, nor was hatching prevented by submitting egg-pods to flooding of the depth and duration to which they were subjected in the field. It is probable therefore that hatching took place and that the absence of hoppers in the Gezira area was due to the lack of suitable food in the few hours following emergence. This subject will be referred to later.

The average periods elapsing between egg-laying and hatching (incubation period) calculated on 105 observed cases from September to January was as follows :-

Month	Number of observations	Average	Minimum	Maximum
September	29	13.4	12	16
October	5	12.8	12	13
November	38	14.9	11	18
December	21	22.8	15	25
January	7	17.8	14	21

A remarkable equality in length is evident, and the normal was only exceeded under conditions of lowered temperature. Thus egg-pods in soil maintained at 15° C. - 18° C., hatched 6.4 days later than those kept at 20° C. - 25° C. Also eggs laid in sand kept saturated showed an incubation period 7 days longer than those in dry sand. The same effects were produced by a drop in temperature during part of December, when the period rose to 22.8 days. The eggs are not surrounded by a resistant layer of cemented

soil and are apparently not able to last over long periods. At least no indications have been forthcoming of a resting stage in the egg.

The hoppers.

These in their early life are uniformly black or dark brown with a narrow white line running back from the head. In the second stage this changes to a black velvety colour on head, and upper parts of thorax and abdomen, and lighter brown or orange below. This external appearance is retained throughout the larval life. There are five moults. The length of the larval period in cages varied little from an average of 23 days if reared in sunlight. If reared in the shade the period lengthened to 40 and up to 56 days. Under natural conditions therefore 20 - 25 days may be taken as the length between hatching and the last moult.

It was found that unless hoppers were given their proper food they died within 48 hours after hatching. This applied to cases in which cotton, lubia (Dolichos lablab) and Ipomoea sp. (Arabic:"tabr") were used. Moreover older hoppers, when removed from their normal food to these plants, all died in about 10 days time. Observations from various sources show that the only food of this locust is grasses or graminaceous crops, and that in the absence of these hoppers cannot exist.

The effect of poisoning on the phase gregaria.

As has been reported elsewhere extensive and successful efforts were made throughout the country to destroy the hoppers.

It was found that the poison bran bait, so efficient a method for the control of the Desert Locust, was equally effective for this species. The best times of day for scattering the bait were early morning and late afternoon and when the larval bands were at rest and not marching. In the latter case they are almost certain to pass over the bait without eating it. Close observations were kept upon certain bands of hoppers both before and after poisoning. Though reliance had to be placed on eye-observation only, it is believed that where 50% to 75% of the hoppers are poisoned the

remaining individuals in a band assume a solitary condition as adults intermediate between the solitary and gregarious phases (phase dissocians) and cease to be dangerous. This condition is characterized by a great diversity of external form but also by an invariably solitary habit. These individuals, the remnants of the previous swarms, live throughout the winter in the place of their origin and are much reduced in number by birds and other animals.

Further observations only can show whether on the return of the rains these individuals are able to multiply once more and give rise to a gregarious phase in situ, but the existence of this ability is believed to be exceedingly doubtful. It would appear nevertheless that a fruitful line of investigation exists in further and more accurate observations on the plasticity of the species and on the exact means required to change one phase to another.

LEAF-CURL OF COTTON.

by

T. W. Kirkpatrick, M.A., DIPL. Agric. (Cantab), F.E.S.

The following is a brief summary of a paper, which is being published elsewhere, giving a full account of the past year's work on leaf-curl, a virus disease which in Sakel cotton gives rise to a condition referred to as leaf-crinkle.

A brief review is given of the very few references in previous literature which are relevant to leaf-curl.

Up to the end of February 1931, 168 straight-forward attempts had been made to transmit "crinkle" from Sakel cotton to Sakel by means of white-flies (Bemisia gossypiperda, Misra and Lamba) of which no fewer than 157 were successful. No transmission was obtained with any other insects.

A single white-fly can transmit the disease to a healthy plant, though infection is less regularly obtained when one, or

only a few white-flies are used.

There is a large amount of negative evidence which indicates that the virus is not transmitted through the seed of Sakel cotton.

There is also no evidence that it can be transmitted through the soil.

In nearly 200 controlled experiments, the incubation period of the virus in the plant varied from 8 to 34 days, but over two-thirds of the recorded periods were between 11 and 19 days.

Possible causes of the variation in the incubation period are discussed.

Little is known with certainty about the factors which influence the severity of the disease.

At least one case of complete recovery from the disease appears to have been observed. Partial recovery is not infrequent.

Details are given of observations and experiments made on three strains of Sakel cotton selected for resistance to crinkle. Though none of them was immune, two at least showed a high degree of comparative resistance, and a greater tendency to recover than ordinary Sakel.

White-flies can pick up the virus from those parts of an infected Sakel plant which show no symptoms, and transmit the disease to healthy Sakel. It is at present rather doubtful whether they can pick up the virus from a plant which has been infected, but before the symptoms develop.

In order to transmit the disease, it is not necessary that white-flies should have fed on crinkly plants as adults, provided that they have done so as larvae.

White-flies which have picked up the virus remain capable of transmitting it for seven days, and very probably throughout their life.

Uninfected adult white-flies can pick up the virus from crinkly Sakel in just over three hours (and possibly in a shorter time). Transmission was however only obtained on two plants out of five, when the time available for picking up the disease was

3 hours 20 minutes. When it was 4 hours 30 minutes or longer, transmission was obtained in every case.

Infected white-flies can transmit the disease to healthy Sakel plants in 30 minutes, and the whole process of infection of the white-flies and of the healthy plant, has been accomplished in 6 hours 30 minutes.

The virus cannot be transmitted through the egg of the white-fly.

Crinkle can be transmitted by white-flies from Sakel cotton to bamia (Hibiscus esculentus, L.) to teel (Hibiscus cannabinus, L.) and to karkade (Hibiscus sabdariffa, L.). The symptoms on these plants resemble fairly closely those on Sakel.

The virus is readily transmitted back from teel to Sakel, but retransmission from bamia to Sakel has not been obtained, although bamia to teel has been.

In order to infect Sakel from bamia it therefore appears necessary to pass the virus through teel.

Crinkle has also been observed on garden hollyhocks.

When white-flies from crinkly Sakel are transferred to American cotton of the variety Watts Long Staple, a conspicuous mosaic is regularly produced, but none of the ordinary symptoms of crinkle appear, except occasionally the faintest traces which do not persist.

Mosaic can also be readily transmitted by white-flies from infected plants of Watts Long Staple to healthy plants of the same variety.

Attempts to transmit it by needle have failed.

No case of complete recovery from mosaic has been recorded, but partial recovery, as with crinkle on Sakel, is not uncommon.

The incubation period of the mosaic manifestation of the virus in Watts Long Staple is similar to that of crinkle in Sakel.

White-flies from crinkly bamia have not produced any symptoms on Watts Long Staple, but typical mosaic is carried by white-flies from crinkly teel.

When white-flies are transferred from Watts Long Staple plants with mosaic to healthy Sakel, no symptoms of either crinkle or mosaic are manifested, but it is shown that such Sakel plants harbour the virus in a masked form, as when white-flies retransmit it from them to healthy Watts Long Staple plants, typical mosaic is produced.

Minor experiments on the transmission of mosaic show that it behaves similarly to crinkle.

Reasons are given for considering that crinkle and mosaic are different aspects of one virus, the symptoms of which vary according to the host plant.

Lists are given of a number of other varieties of cotton to which transmission of the virus by white-flies has been attempted. Some of these develop crinkle only, some mosaic only, a few may show the symptoms of both crinkle and mosaic in the same plant, while on same - particularly Asiatic cottons - no symptoms have been produced. There is no indication that such plants harbour the virus in a masked but transmissible form. A few minor transmission experiments are described.

Possible virus diseases have been observed on "lubia" (Dolichos lablab, L.), French beans, and "gubein" (Solanum dubium, Fresen.). These however, if virus diseases at all, seem to have no connection with crinkle-mosaic of cotton.

A very similar condition to crinkle of cotton has been observed on tomatoes. Further experiments are required before it can be said whether the disease are identical.

During the 1930-31 season in the Gezira, leaf-crinkle spread earlier and faster than during the previous season, and the general intensity of the disease was more severe. The extent of the damage caused by it is not known with any certainty, but is believed to be between one half and one kantar per feddan. Apart from the selection of resistant strains of cotton, the only possibilities for the control of crinkle lie in control of the white-flies or control of the initial sources of infection early in the season. The former is being investigated by another worker. It is believed that the virus is carried over from one season to the next, at any

rate mainly, in the "ratoon" cotton plants which survive the "dead season" and produce new growth - which is almost always crinkly when the land which had been under cotton is irrigated for lubia and dura in August.

It is hoped that the new rotation proposed by the Sudan Plantations Syndicate will make it possible to eradicate this "ratoon" cotton.

Thrips affecting the Cotton Crop in the Gezira in 1930.

by

W. P. L. Cameron, B.Sc., D.I.C.

As a paper on this subject is in preparation for publication, a general outline of the work done during the year is given here as briefly as possible. It includes notes on the species concerned and their habits, and also results of experiments and control measures.

Perhaps the two most striking features of the year's work have been, firstly, the establishment of the fact that the Gezira cotton crop is subject to the depredations of two species of Heliothrips which attack the leaves of the plant instead of one, namely, Heliothrips indicus, Bagnall., as was formerly thought to be the case and, secondly, the first record of damage done to the crop by certain species of thrips of another genus, so far undetermined, which live in the buds and cause malformations of the leaves and retarding of growth, particularly of later-sown plants.

The Species Concerned.

(a) The Leaf Species.

In the past it was considered that Heliothrips indicus, Bagn. was the only species which affected the yield of the crop. Of late,

however, suspicions have been aroused chiefly owing to the variations in the colour of the larvae. No great dissimilarity between the adults of the two species exists, as seen by the naked eye or hand lens, except that Heliothrips indicus is usually lighter in colour than the other and more important darker species. The latter has so far not been identified by the Imperial Institute of Entomology and so is here referred to as Heliothrips sp. It should be stated that variation in colour is rather a characteristic feature of certain related thrips, and has contributed not a little to the confusion which has existed.

As regards the larval coloration, H. indicus has a yellowish head and anterior half of the thorax and almost always possesses red bands at both ends of the abdomen, whereas Heliothrips sp. is more variable and is usually white or greyish in general appearance with the first and last few segments of the abdomen either yellowish or orange in colour. Sometimes the larva even assumes a general reddish tinge. These variations in this particular species are apparently the result of environmental conditions as the orange and red forms commonly appear when the larvae are reared in an atmosphere of high humidity. This explains why these highly coloured varieties are only to be found in the field during the rainy season.

The effect of excessive humidity is less apparent on the adults but a darkening in colour can be detected. With regard to the habits of the two species, further differences can be seen in the field as will be seen later. A third species of Heliothrips which has been receiving attention is one which confines its activities to grasses, such as Sorghum spp., Cymbopogon nervatus, Chiov. (Arabic: "naal"), Echinochloa colona, Link. (Arabic: "defera"), etc. It closely resembles H. indicus but its larva, when full-fed, is white in colour. It can only be found during the rains and disappears about October. Its relationship, if any exists, with the two foregoing species is not yet understood and further work is essential before a statement can be made.

(b) The Bud Species.

At least two species of thrips have been observed living in the young buds of the cotton plant but it is thought that one of these, which is straw-coloured, both as an adult and as a larva, is more important than the other, and by its activities causes curling and malformation of the leaves. It is particularly severe on later-sown plants, completely retarding their growth during the dry hot weather following the rains. On the arrival of the cold weather the activities of the insects diminish and the cotton plants then get a chance to recover.

This is the first time that these thrips have been recorded as pests in the Sudan, being noticed this year chiefly owing to the severity of their attack. Other plants which have been observed to be similarly attacked by them are Leucas urticaefolia, Benth., (Arabic: "um galot"), Ocimum basilicum, L. (Arabic "rehan"), Ipomoea spp. (Arabic: "tabr" and "hantut") and mango trees. Probably there are many more.

Field Notes on the Abundance of Heliothrips spp. during the year and Control Measures carried out.

During the first half of the year thrips were not much in evidence, occurring chiefly on their weed host plants and Medicago sativa, L., (Arabic: "berseem"). On cotton, Heliothrips indicus, Bagn., was moderately common and showed the usual slight increase in April and May. On the arrival of the rains the numbers of both species decreased considerably until about the end of July. Evidence is becoming stronger that Heliothrips and other Terebrantian thrips in the Gezira pass through the summer resting either as pupae or as adults in the soil. During August thrips generally became more active, encouraged by the hot dry weather then prevailing. The grass Heliothrips was very common on the Sorghums (Arabic: "dura" and"addar"), "naal" and "defera". Heliothrips sp. was common on cotton on which it was observed for the first time on August 11th., Dolichos lablab, L. (Arabic. "lubia afin"), Polygala erioptera, DC. (Arabic: "um hibeiba"),

Heliotropium sp. (Arabic: "dokhan el azabat"), Crotalaria sp. (Arabic: "safeira") etc.

The heavy rains at the end of August, while severely checking the thrips, encouraged the weeds which had hitherto been rather scarce. A further dry spell in September combined with ample attractive food caused renewed thrips activity. Heliothrips indicus was then numerous on "um galot". By the end of September the weeds began to dry up, and the second and chief migration of Heliothrips sp., in particular to cotton and "lubia", took place. As this happened about a fortnight earlier than in 1929 it was expected that fairly serious damage to cotton might result during the hot October and early November weather. During the first week of October it became obvious that unless something was done serious damage would occur. It was then decided, as a preventive measure, to reduce the interval (15-17 days) between waterings to ten days. With the cotton and the "lubia" crops throughout the Gezira requiring an increased water supply at this time, a shortage of water resulted. In consequence of this a survey of the infested areas was made in order to economies as much water as possible and apply increases only where necessary. It was found that the areas of greatest infestation were mainly in Ghubshan, Wad Naaman and Hosh Blocks, and particularly in areas of later sowing. After the application of the treatment beneficial results were observable. Certain areas were kept under almost daily observation and the records of adults thrips emerging per unit area obtained, showed that the treatment had been efficient in completely preventing a further outbreak. Moreover, no detrimental effect to the cotton, such as increased blackarm, could be seen in these places. Those areas which were reported to have suffered from excessive soil moisture were chiefly ones of earlier sowing, not necessarily attacked by thrips, but which, owing to the rigidity of the irrigation system, had also to receive increased waterings by reason of their being situated on the same canal as infested areas. However, work on this subject is being continued in the coming year, and the possibility of reducing the watering interval

between the second and third and third and fourth irrigations merely to twelve days is being considered.

After the application of the extra water which took place during October, few Heliothrips were to be seen on the cotton in the South until the last week of December when H. indicus was the commonest species. It is interesting to record that there was only one other report of thrips damage during this period and that came from Efeina Block where no thrips control measures had been undertaken.

Field Experiments.

(a) The growing of Cajanus indicus ("ads sudani") Spreng. on the higher ridges of the cotton fields, i.e. along the watering channels and around the edges, was undertaken in numbers 1 and 7 of Bilawi canal in Ghubshan Block, as a preventive measure against cotton thrips.

The result was disappointing owing to the fact that Cajanus in its early stages requires more water than cotton. The plants round the edges, where they were most required, suffered severely from drought and were readily destroyed by termites. Further, great difficulty was experienced in getting the tenants to sow and resow the Cajanus early enough.

(b) The Cultivation of Crotalaria sp. ("safeira") as a possible trap crop for Cotton Thrips. The suitability of this common weed as a Heliothrips trap plant in the southern Gezira has already been proved but as little was known about its cultivation this experiment was started. Seed was sown in small plots, partly on the flat and partly on low ridges, at fortnightly intervals from mid-August to mid-October. As there was little to choose between the various treatments, it may be conduced that this Crotalaria can be grown readily at any period during the rainy season provided a sufficiency of water is available.

Other Investigations.

Regular collections of Heliothrips were made throughout the

year from a variety of host plants. These showed that females are as a rule about twice as numerous as males; during the early part of the year the proportion appears to be even greater. This preponderance of females, whose fecundity is high, combined with the fact that parthenogenesis can readily take place, gives an explanation of why these insects are capable of multiplying so rapidly as soon as suitable conditions arise.

Heliothrips sp. affecting the Rain-grown American Cotton at Galaa el Nahl, Kassala Province.

Report of Experimental Work for 1930.

by

W. P. L. Cameron, B.Sc., D.I.C.

The most important insect pest to which the cotton crop in southern districts of Kassala Province is liable annually is Heliothrips sp., which causes severe defoliation with consequent reduction in yield. So severe has been its damage in recent years that it has come to be considered a limiting factor in the production of cotton. It has been responsible for the abandonment of cotton growing in the Gedaref area while in the Galaa el Nahl and Ban areas only the most enthusiastic cultivators continue to grow the crop. Under these circumstances, an investigation into the habits of Heliothrips in these parts with a view to finding some means of control was considered essential. The following is a description of the first experiments undertaken and the results obtained appear to be encouraging in affording a solution to the problem.

Experimental Work.

The main experiment was one designed to give information as to the effect of the date of sowing of the crop on the degree of

thrips infestation. An area of six feddans (1 feddan = 1.038 acres) was prepared and divided into six one-feddan sub-plots, one for each treatment.

Five dates of sowing, viz. June 15th., July 1st. and 15th., August 15th. and September 15th., were selected for five of the sub-plots while the remaining sub-plot was divided into two equal parts and devoted to August 15th. sown cotton with two variations in the spacing of the plants.

Webber seed was used and sown on the flat by "seluka" (or dibble) in rows 80 cms. apart. The distance between the plants in each row in the main experiment was 80 cms. while in the narrow spaced half sub-plot it was 40 cms. and in the widely spaced area 120 cms. Resowing was done as soon as possible after the original date of sowing in each case and once only.

Three or four weeks after sowing the crop was thinned to three plants per hole.

The results were based on eye observations and sub-plots yields and are given in tabulated form for brevity.

Sub-plots	Germination	Type of Plants	+ Yield in Rottle per Feddan	Thrips Infestation
June 15th.	Poor owing to deficient rain-fall.	Excellent	207	None
July 1st.	Excellent	Excellent	304	None
July 15th.	Excellent	Good	191	Very slight
August 15th. (ordinary spacing)	Good	Good but suffered from drought later	74	Heavy
August 15th (narrow spacing),	Good	Poor and spindly	26	Fairly heavy
August 15th. (wide spacing)	Good	Good but too wide apart	62	Moderate
September 15th:	Very good	Poor	Nil	Very severe

+ 1 Rottl = 0.99 lb = 450 gms.

Conclusion.

In consequence of these results and of observations made in previous years, it is essential, if American cotton is to be grown in this area under rain conditions, that the crop must be sown as early in the rainy season as possible - the best period for sowing being during the last week in June and the first week or two in July in most years. After mid-July sowing should be discontinued as poor crops merely result and these act as sources of thrips infestation endangering the earlier sown cotton nearby.

The writer begs to acknowledge the kind assistance of the Agricultural Inspector at Gedaref in carrying out the cultural part of these experiments.

The weed "hambuk" (Abutilon spp.) and the part it plays in the conservation of parasites of the various species of bollworm which attack cotton in the Sudan.

By

H. W. Bedford, F.E.S.

Assistant Entomologist.

For many years the weed hambuk (Abutilon spp.) was regarded in the Sudan in the light of a serious menace to the cotton crop. There was in fact ample evidence to justify this point of view for not only is this weed a favourite food-plant of certain pests of cotton including the Egyptian or Spiny bollworm (Earias insulana, Boisd.), and also but of less importance the cotton flea-beetle (Podragrica puncticollis, Wse.), and the cotton seed-bug (Oxycarenus hyalinipennis, Costa), but being a hardy perennial it also acts as a suitable host for these insects during the "dead season" for cotton. For sometime it was feared that being a Malvaceous weed closely allied to cotton its fruits might attract the pink bollworm

(Platyedra gossypiella, Saunders), particularly as in 1917 King (The weed Hambuk (Abutilon spp.) and its relation to the cotton growing industry in the Anglo-Egyptian Sudan, W.T.R.L.Ent.Bull. No.7) recorded an instance of the latter having been found attacking hambuk. The statement however did not originate from King but from another worker who not being an Entomologist might very easily have mistaken the larva of Crocidosema plebeiana, Zell., an insect commonly to be found in hambuk, for the pink bollworm owing to the very striking resemblance the former often bears to the latter. As moreover there has been no further record of the occurrence of pink bollworm on hambuk it is extremely likely that the statement was erroneous. According to Wilcocks (The insect and related pests of Egypt Part I. The Pink Bollworm 1916 pp. 104-105 both bamia (Hibiscus esculentus, L.) and teel (Hibiscus cannabinus, L.) appear to be less favoured as food-plants by the pink bollworm than cotton, and the same may be said to be true in the Sudan but to a far greater extent, for it is comparatively rare to find pink bollworm attacking any plant other than cotton, and there is no apparent reason for supposing that this pest is likely to be attracted to hambuk in the future.

Until recently the policy recommended with regard to hambuk has been its eradication or rather control along with other Malvaceous plants in all cotton areas during the "dead season" for this crop, the main object of which has been the control of the Egyptian bollworm. From this point of view the measure undoubtedly has its merits but to be really successful it must be widely and rigidly carried out owing to the possible migration of moths from one area to another. It is the writer's opinion that if hambuk be entirely controlled [illegible] and not in another there is a great liability of moths migrating from the latter to the former, and further that if in the former area hambuk control is continued during the cotton season the cotton itself is liable to heavy infestation by this bollworm. If on the other hand hambuk is controlled only during the dead season and

encouraged to flower and fruit during the cotton season the majority of Egyptian bollworm moths will be attracted to the hambuk rather than to the cotton.

The great disadvantage resulting from the measure preventing the flowering and fruiting of hambuk during the "dead season" is that at least three of the most efficient parasites of the different species of bollworm are deprived of hosts to tide them over the dead season and enable them to multiply sufficiently so as to make their presence felt as soon as the bollworms attack the cotton. The species chiefly affected in this way are Microbracon kirkpatricki Wlkn., Apantales carterus, Wlkn., Elasmus johnstoni, Ferr. and probably to some extent Microbracon brevicornis, Westw. Of these the first named is at present the most effective of the parasites of the pink bollworm and has as an alternate host the larva of Crocidosema plebeiana, on which it breeds during the dead season. Apantales carterus and Elasmus johnstoni parasitise both the Egyptian bollworm and the Sudan bollworm (Diparopsis castanea, Hampson) and are able to tide over the "dead season" by attacking the former host in hambuk fruits. It is possible of course that either or both of these parasites have another or other hosts but as yet none is known. Microbracon brevicornis has a large number and variety of hosts and it is therefore doubtful whether this parasite is dependent on a single one to tide it over the dry season. In addition there are other occasional parasites of the bollworm which are at times bred out from Earias insulana contained in hambuk fruits, but they appear to be of little consequence.

During the year under review a further study was made of the incidence of parasites attacking Earias insulana and Crocidosema plebeiana in hambuk fruits. Samples consisting of 4,000 fruits were collected each month (with the exception of December owing to the pressure of other work) from Shambat Farm at Khartoum North and also but at irregular intervals from other stations including Medani, Shendi and the Mogren at Khartoum. The fruits were placed

in cages and the various insects which emerged noted. The results of the experiment may be summarised as follows :-

The emergences of Crocidosema plebeiana, which were never high, showed little variation from month to month with the exception of April and May when none were obtained, although from the samples taken during these two months 1 and 49 M. kirkpatricki respectively bred out showing that Crocidosema had been present but was parasitised. The highest figure for Crocidosema in any month at Shambat was 9 which was obtained in July and the average for the months July - November was 7. There was however considerable variation in the figures for M. kirkpatricki namely from 1 in April to 121 in August and October while the average for the period July - October was 109. From the above it would appear that Crocidosema is able to breed throughout the year on hambuk but is at all seasons liable to parasitism by M. kirkpatricki. The unfavourable period for the former would seem to be April - June which approximately coincides with the dead season. During that time hambuk flowers and fruits very little particularly if deprived of irrigation water. As soon as the rainy season starts hambuk again flourishes and there is a strong indication that Crocidosema increases but so also does its parasite and the latter obtains and retains the upper hand. If allowed to continue breeding during the dead season M. kirkpatricki becomes very active in July and continues so for at least 4 months on hambuk which coincides with the early attack of the pink bollworm in the cotton crop, a period when the parasite's activities are particularly required so as to keep the bollworm in check. Of recent years the pink bollworm has become more and more a serious pest in Berber Province owing, it is believed, to the difficulties of carrying out the control measures recommended, which have been found successful in other cotton areas. It is considered that to counteract this evil more might be done to encourage biological control. Under present conditions M. kirkpatricki only becomes effective as a parasite of the pink bollworm towards the latter part of the

cotton season, but if its presence in large numbers could be assured early in the season when the bollworm first appears it is believed that a state of natural control would be achieved.

An experiment has been planned to be carried out during the coming season at one of the Government Pumping Stations in Berber Province, which entails the growing of hambuk during the dead season along the main irrigation canals bordering fields reserved for cotton. No definite results however can be expected from such an experiment during the first year as hambuk will not have had a chance of establishing itself sufficiently. In carrying out an experiment of this nature fear may be felt that the Egyptian bollworm will be encouraged and allowed to increase to the danger of the cotton. From all samples of hambuk fruits collected from Shambat last year, Egyptian bollworm was obtained showing that it apparently breeds on hambuk throughout the year but like Crocidosema is least conspicuous during the period April - June and tends to increase again on the advent of the rains. The average number of Egyptian bollworm which emerged from samples taken during July to November was 44 whilst the maximum of 117 was reached in January and from the latter sample 63 M. brevicornis bred out. This parasite appeared to be only numero on hambuk from January to March, the highest number emerging from a single sample which was obtained from the Gezira in March being 72. Both Apantales carterus and Elasmus johnstoni appeared to have a somewhat similar periodicity in hambuk to M. brevicornis, the maximum number of the former obtained from a single sample (in February) being 15 as compared with 68 of the latter from a Gezira sample in March. By encouraging hambuk during the "dead season" it is hoped that the last three parasites will increase at the expense of the Egyptian bollworm.

Furthermore as demonstrated by King in Entomological Bulletin No. 7 already quoted and from the experiences of the writer both at Tokar and in Berber Province there is every indication to show that where hambuk flourishes during the cotton season the former is liable to heavy infestation by the Egyptian bollworm while the latter seems to remain comparatively free.

Publications.

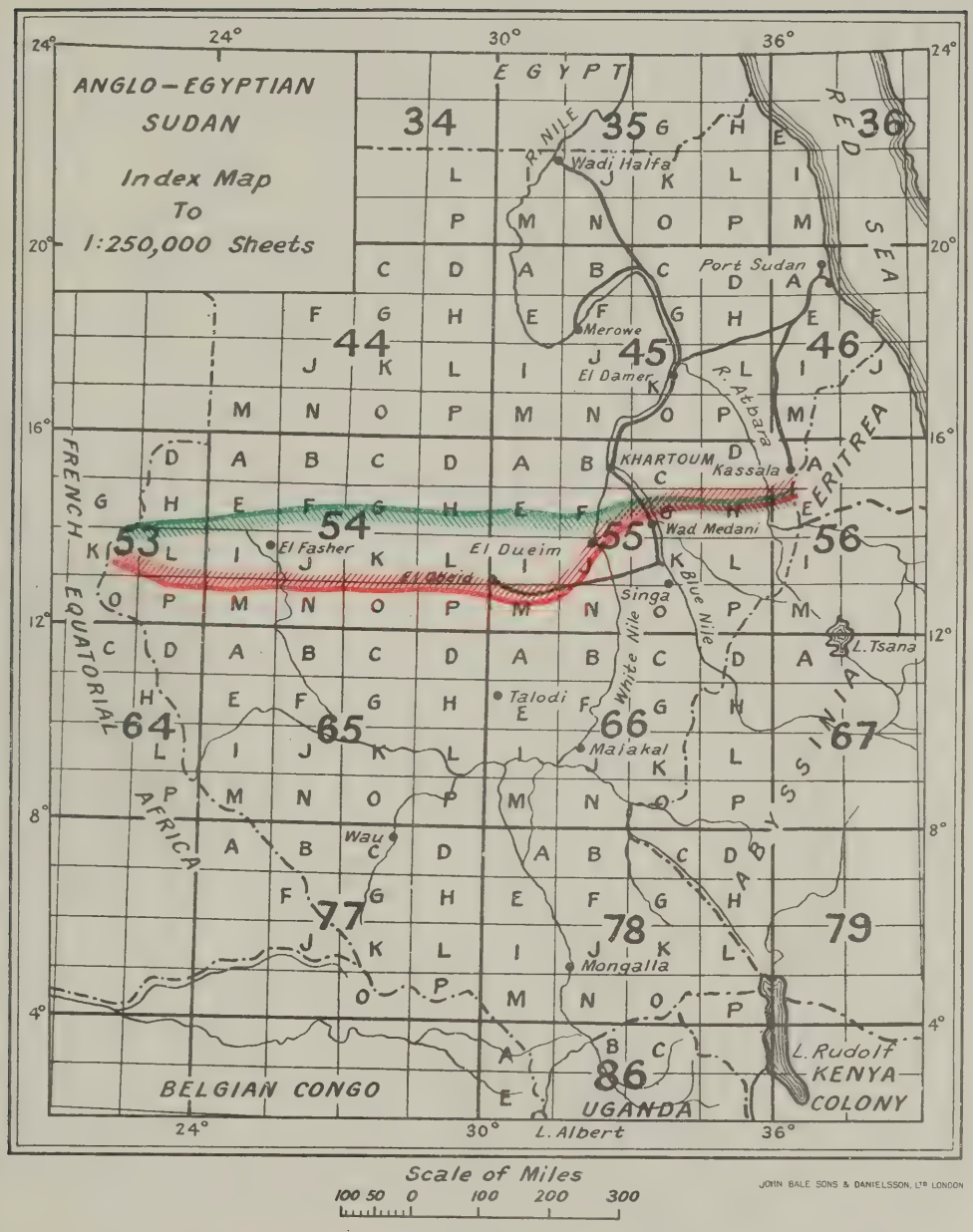
The following papers have been published during the course of the year :-

1. Report of the Government Entomologist for the year 1929. By H. H. King. (W.T.R.L. Ent. Bull. No. 31).
2. The Desert Locust (Schistocerca gregaria, Forsk.). By H. H. King. (W.T.R.L. Ent. Bull. No. 30).
3. Preliminary note on leaf-crinkle of cotton in the Gezira Area, Sudan. By T. W. Kirkpatrick. (Bull. Ent. Res. Vol. XXI., Pt. 2, July 1930).
4. A description of the methods adopted in the Sudan in the organisation of the insect collection and the systematic compilation of records. By H. W. Bedford. (W.T.R.L. Ent. Bull. No. 32).
5. The distribution of tsetse-flies in the Sudan. By H. W. Bedford. (Bull. Ent. Res. Vol. XXI., Pt. 3, October 1930).
6. Notes on Argas brumpti (Acarina). By W. Ruttledge. (Bull. Ent. Res. Vol. XXI., Pt. 3, October 1930).
7. The Sudan Bollworm (Diparopsis castanea, Hamp.), in the Sudan. By W. E. Giffard. (W.T.R.L. Ent. Bull. No. 27).

The following papers are awaiting publications :-

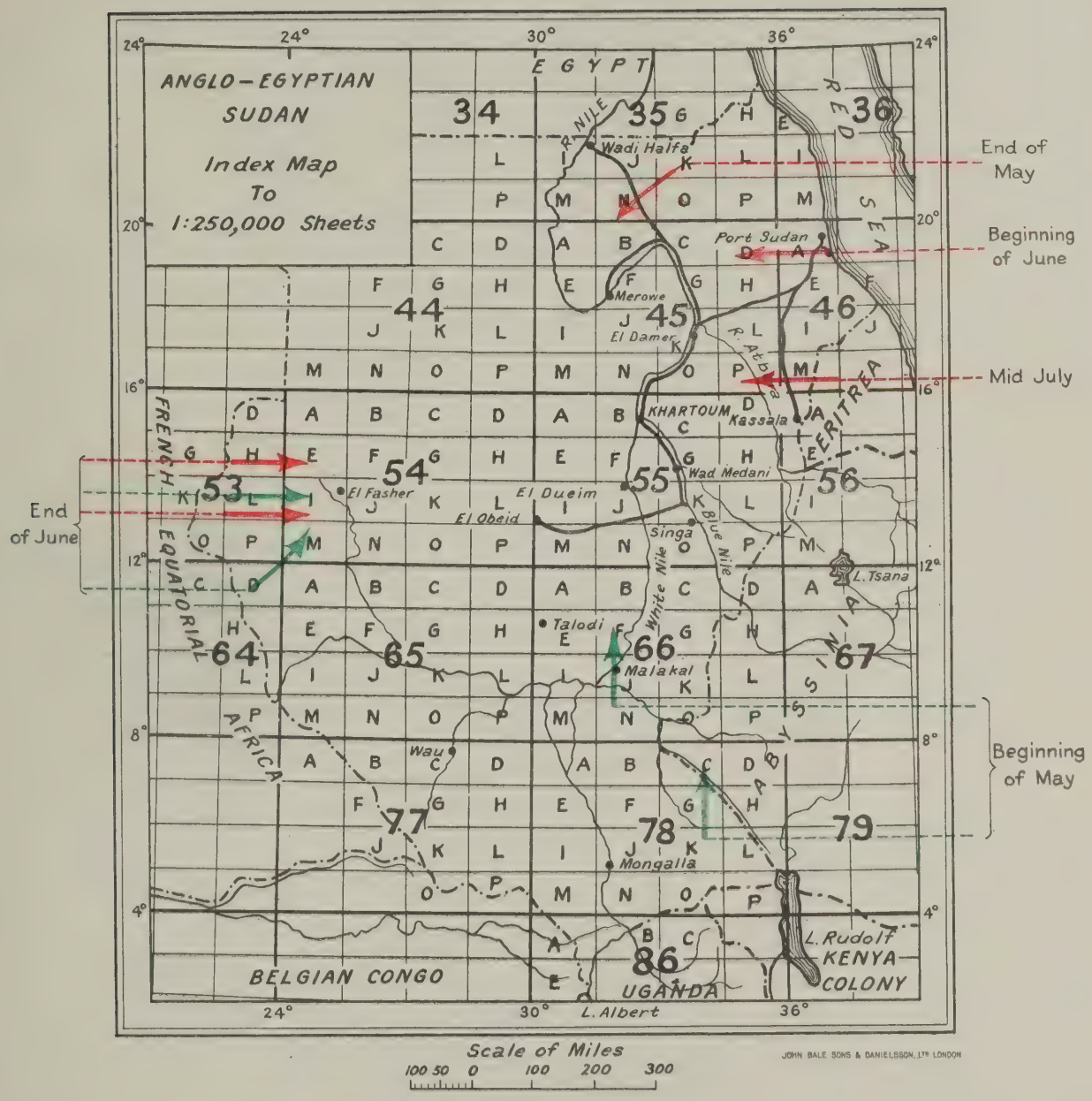
1. A catalogue of the insect fauna of the Sudan with notes on their status and habits, distribution and periodicity. Part I. Coleoptera. By H. W. Bedford. (W.T.R.L. Ent. Bull. No. 33).
2. The Sudan Millet Bug (Agonoscelis versicolor, F.). Its economic importance and control. By F. G. Sarel-Whitfield. (W.T.R.L. Ent. Bull. No. 28).
3. Notes on two locusts of minor economic importance in the Sudan. By H. B. Johnston.
4. On the occurrence in the Sudan of Locusta migratorioides Rch. and Frm., and its associated phases. By H. B. Johnston and R. C. Maxwell-Darling.
5. Further studies on leaf-crinkle of cotton in the Sudan. By T. W. Kirkpatrick.

PLATE I.



Map of the Sudan showing the approximate southern limit of breeding of *Schistocerca gregaria* & the northern of *Locusta migratorioides*.

PLATE II.



Map showing lines of emigration into the Sudan of *Schistocerca gregaria* & *Locusta migratorioides* during 1930.

BULLETINS AND CIRCULARS.

Published by the Entomological Section,

Wellcome Tropical Research Laboratories, Khartoum.

Entomological Circulars.

No. 1. Directions for the Collection of Blood-sucking Insects and Ticks. Published in English and Arabic (Out of Print).

No. 2. An Injurious Weed (Abutilon graveolens). Published in English and Arabic. By H. H. King.

No. 3. Dura Asal Fly. Published in English and Arabic. By H. H. King. (Out of Print).

No. 4. The Asal Fly on Dura in Dongola Province. Published in Arabic. By H. H. King.

No. 5. The Pink Bollworm at Tokar. Published in Arabic. By H. H. King.

No. 6. The Clothes Beetle (Anthrenus vorax). Published in English and Arabic. By H. H. King.

No. 7. Locusts. Published in Arabic. By H. H. King.

Entomological Bulletins.

No. 1. Locust Destruction. Published in English and Arabic. By H. H. King. (Out of Print).

No. 2. The Dura Asal Fly (Aphis sorghi, Theob.) in Dongola Province. Published in English. By H. H. King.

No. 3. The Migratory Locust (Schistocerca peregrina, Oliver) and its Control. Published in English. By H. H. King. (Out of Print).

No. 4. The Pink Bollworm (Gelechia gossypiella, Saunders) in the Anglo-Egyptian Sudan. Published in English. By H. H. King (Out of Print).

No. 5. The Pink Bollworm (Gelechia gossypiella, Saunders) and Measures for its Control. Published in English. By H. H. King. (Out of Print).

No. 6. The Sudan Cotton Bollworm (Diparopsis castanea, Hampson). Published in English. By H. H. King. (Out of Print).

No. 7. The Weed Hanbuk (Abutilon spp.) and its Relation to the Cotton Growing Industry in the Anglo-Egyptian Sudan. Published in English. By H. H. King. (Out of Print).

No. 8. Clean Cultivation in its Relation to the Control of Insect Pests. Published in English. By H. H. King. (Out of Print).

No. 9. The Control of Insect Pests of Cotton. Published in English. By H. H. King.

No.10. The Pink Bollworm (Pectinophora (Gelechia) gossypiella, Saunders) at Tokar, during the season, 1917-1918. Published in English. By H. H. King.

No. 11. A Beehive designed for the Production of Beeswax suitable for use by natives of the Southern Sudan. Published in English. By H. H. King.

No. 12. The Migratory Locust (Schistocerca peregrina, Oliver). Published in English. By H. H. King.

No. 13. Rats and Mice. Published in English. By H. H. King.

No. 14. Hyaenas. Published in English. By H. H. King.

No. 15. The Locust. Published in English and Arabic. By H. H. King.

No. 16. The Fowl Tick (Argas persicus, Oken). By H. H. King.

No. 17. The Asal of Cotton and its Causes in the Sudan. By H. W. Bedford. (Out of Print).

No. 18. The Cotton Thrips (Heliothrips indicus, Bagnall) in the Sudan, with a description of its history and habits in the Gezira (Blue Nile Province), and Measures for its Control. By H. W. Bedford. (Out of Print).

No. 19. The Pests of Cotton in the Anglo-Egyptian Sudan, with Description of the Damage caused to the Plant and Measures recommended for their Control. By H. W. Bedford. (Out of Print

No. 20. The Spanish Sparrow (Passer hispaniolensis, transcaspicus Tschusi. A Pest of Grain Crops in Dongola Province. By H. H. King.

No. 21. The Control of the Pink Bollworm (Platyedra gossypiella, Saunders) in the Sudan. By H. H. King and W. E. Giffard.

No. 22. A Further Contribution to our Knowledge on the Bionomics and Control of the Migratory Locust (Schistocerca gregaria Forsk, peregrina, Oliv.) in the Sudan. By H. B. Johnston. (Out of Print).

No. 23. The Ticks (Ixodoidea) of the Sudan. By H. H. King.

No. 24. Report of the Government Entomologist for the year 1926. By H. H. King.

No. 25. Report of the Government Entomologist for the year 1927. By H. H. King.

No. 26. Pink Bollworm (Platyedra gossypiella, Saunders) in the Gezira District of the Sudan in 1927 and 1928. By H. Bennett Johnston.

No. 27. The Sudan Bollworm (Diparopsis castanea, Hamp.) in the Sudan. By W. E. Giffard.

No. 28. The Dura Andat (Agonoscelis versicolor, F.). By F. G. S. Whitfield.

No. 29. Report of the Government Entomologist for the year 1928. By H. H. King.

No. 30. The Desert Locust (Schistocerca gregaria, Forsk). By H. H. King.

No. 31. Report of the Government Entomologist for the year 1929. By H. H. King.

No. 32. A Description of the methods adopted in the Sudan in the organisation of the insect collection and the systematic compilation of records. By H. W. Bedford.

No. 33. A catalogue of [redacted]t fauna of the Sudan with notes on their status and habits, distribution and periodicity. Part I. Coleoptera. By H. W. Bedford.

No. 34. Report of the Government Entomologist for the year 1930. By H. H. King.

Copies of Entomological Circulars and Bulletins may be obtained from the Government Entomologist, Khartoum.

UNIVERSITY OF ILLINOIS-URBANA
3 0112 072421032